Bureau canadien de la sécurité aérienne

Canadian Aviation Safety Board

Rapport d'un fait aéronautique civil

Civil Aviation Occurrence Report

Canada

The Canadian Aviation Safety Board investigated this occurrence for the purpose of advancing aviation safety. It is not the object of the Board to determine or apportion any blame or liability.

AVIATION OCCURRENCE REPORT

CANADIAN AIRLINES INTERNATIONAL LIMITED
BOEING 737-275C C-GFPW
NEAR PRINCE GEORGE AIRPORT,
BRITISH COLUMBIA
24 NOVEMBER 1987

REPORT NUMBER 87-P74128

SYNOPSIS

The aircraft was on a scheduled flight from Vancouver to Prince George, British Columbia. During the instrument approach to the Prince George Airport and while the aircraft was flying in cloud, the aircraft's ground proximity warning system twice sounded an alert. After the first alert, the crew climbed to a safe altitude, and then, believing the warning invalid, the pilots resumed the descent. About four minutes later, the airport controller warned the flight crew that the aircraft was well east of the published approach track, and, at about the same time, the second alert sounded. The crew discontinued the approach and climbed to a safe altitude. Another approach was flown, and the aircraft was landed without further incident.

The Canadian Aviation Safety Board determined that the captain mis-selected the VHF NAV transfer switch and the pilots did not confirm that the selection produced the desired results, nor did they use all available aids during the approach. Contributing factors were the lack of a positive indication of the source of navigation information displayed on the HSI, the crew's lack of familiarity with this aircraft cockpit configuration, and inadequate training and operational guidance provided by the company. The training standards met Transport Canada guidelines; the guidelines did not include cockpit familiarization.

The air traffic controllers did not ensure that the crew was aware that the aircraft had deviated from the published approach track in time to prevent the near collisions with the ground.

Ce rapport est également disponible en français.

20 February 1990

TABLE OF CONTENTS

		Page
1.0	**FACTUAL INFORMATION**	1
1.1	History of the Flight	1
1.2	Injuries to Persons	4
1.3	Damage to Aircraft	4
1.4	Other Damage	4
1.5	Personnel Information	4
1.5.1	Pilots	4
1.5.2	Air Traffic Controllers	5
1.6	Aircraft Information	6
1.7	Meteorological Information	6
1.8	Aids to Navigation	7
1.8.1	Aircraft Navigation Aids	7
1.8.2	Airport Navigation Aids	7
1.8.3	Automatic Direction Finding (ADF) Errors	7
1.8.3.1	Precipitation Static	7
1.8.3.2	Mountain Effect	7
1.8.4	Tower Very High Frequency Direction Finder (VHF)	8
1.8.5	Air Traffic Control Radar	8
1.8.6	Very High Frequency Navigation (VHF NAV) Receivers	8
1.8.7	Distance Measuring Equipment (DME) Hold	8
1.8.8	VHF NAV Transfer Switch	8
1.8.9	Horizontal Situation Indicator (HSI) Displays	9
1.8.10	Attitude Director Indicator (ADI) Displays	10
1.8.11	Approach Procedure - Runway 33	10
1.8.12	Approach Preparation	10
1.9	Communications	11
1.9.1	ATC Radio Procedures	11
1.9.2	Aircraft VHF Radios	11
1.10	Aerodrome Information	12
1.11	Flight Recorders	12
1.11.1	Digital Flight Data Recorder	12
1.11.2	Cockpit Voice Recorder	12
1.12	Wreckage and Impact Information	13
1.13	Medical Information	13
1.14	Fire	14
1.15	Survival Aspects	14
1.16	Tests and Research	14
1.17	Additional Information	15
1.17.1	Operating Certificate and Flight Operations Manual	15
1.17.2	Company Training - Combi Aircraft	15
1.17.3	Aircraft Assignment	16
1.17.4	Ground Proximity Warning System (GPWS)	16
1.17.4.1	Mode 2A (Flaps Up)	16
1.17.4.2	Mode 2B (Flaps Down)	16
1.17.4.3	GPWS Warning Analysis	17
1.17.5	Descent Procedure	17

1.17.6	Engine Anti-Ice	18
1.17.7	VHF NAV Receiver Assignment	18
1.17.8	ATC Controller Duties	18
1.17.8.1	Flight Information	18
1.17.8.2	Direction Finding (DF) Service	19
1.17.8.3	ILS Operation	19
1.17.8.4	Emergencies	19
1.17.9	Prince George Tower Operations	19
1.17.10	Maps	19
1.17.11	Approach Event Timing	20
2.0	**ANALYSIS**	**21**
2.1	Introduction	21
2.2	Aircraft Assignment	21
2.3	Weather	21
2.4	Approach Options	21
2.5	VHF NAV Transfer Switch	22
2.6	VHF Navigation Receiver Assignment	22
2.7	Horizontal Situation Indicator and Attitude Director Indicator Information	23
2.8	ADF Navigation Receivers	25
2.9	VHF Communications Radios	25
2.10	Digital Flight Data Recorder	26
2.11	Ground Proximity Warning	26
2.12	Medical	26
2.13	Air Traffic Control	26
3.0	**CONCLUSIONS**	**28**
3.1	Findings	28
3.2	Causes	30
4.0	**SAFETY ACTION**	**31**
4.1	Action Taken	31
4.1.1	Ground Proximity Warning System (GPWS)	31
4.1.2	VHF Navigation Transfer Switch	31
4.2	Further Action Required	31
4.2.1	Cockpit Resource Management Training	31
4.2.2	Navigation Instrument Displays	32
4.2.3	Cockpit Voice Recorder (CVR) Recording Time	33
4.2.4	Standardization	34
4.3	Safety Concerns	35
4.3.1	Controller Assertiveness	35
4.3.2	Use of Halcion	36

5.0 APPENDICES

APPENDIX A - APPROACH CHART A-1
APPENDIX B - AREA MAP B-1
APPENDIX C - VHF NAVIGATION C-1
APPENDIX D - VHF NAVIGATION SYSTEMS SCHEMATIC . D-1
APPENDIX E - HORIZONTAL SITUATION INDICATOR (HSI) E-1
APPENDIX F - ATTITUDE DIRECTOR INDICATOR (ADI) F-1
APPENDIX G - VHF COMMUNICATION SYSTEMS COMPONENT LOCATION G-1
APPENDIX H - GLOSSARY H-1

1.0 FACTUAL INFORMATION

1.1 History of the Flight

The captain and first officer arrived at the Vancouver International Airport on the morning of 24 November 1987 to prepare for Canadian Airlines International Limited (CAIL)* Flight 180 to Prince George, British Columbia. The aircraft assigned for the flight was a Boeing 737 Combi that could be configured to carry a combination of passengers and cargo. The aircraft had been formerly operated by Pacific Western Airlines (PWA). The flight crew were former employees of Canadian Pacific Airlines (CPAL) and had not flown a Boeing 737 in this configuration, but they had attended the company's conversion ground school course on the aircraft. Before departing on this flight, they took some time to familiarize themselves with the cockpit layout and to review the aircraft's operating procedures. This caused a delay which was compounded by other delays due to boarding passengers and to traffic. As a result, the flight departed Vancouver at 0830 Pacific standard time (PST)**, 30 minutes behind schedule.

The first officer was flying the aircraft, and the flight was approaching the Prince George Airport from the south on the airway J541. The crew planned for an instrument approach to runway 15 because the surface wind was from the south, and the flight attendants requested extra time to prepare the passenger cabin for landing.

As the flight approached destination, the Prince George Sector Radar Controller advised the Prince George Airport Controller that the aircraft would arrive at 0915 PST. The radar controller then advised the crew to expect an approach to runway 33. The crew was also told to follow the airway to the CHUBB intersection and then to intercept and fly the runway 33 instrument landing system (ILS) localizer back course. (See Appendix A.)

The descent profile that the pilots planned for runway 15 was not suitable for runway 33 because the aircraft was too close to the airport, and a more rapid descent was required. The captain accepted the approach to runway 33.

* See Glossary for all abbreviations and acronyms.
** All times are PST (Coordinated Universal Time (UTC) minus eight hours) unless otherwise stated.

At 0906 PST, the radar controller cleared the flight to the Prince George Airport via the straight-in, back course instrument approach to runway 33 and told the crew to contact Prince George Tower. The captain was unable to contact the tower using the aircraft's number one very high frequency (VHF) radio; however, he was successful with the number two radio. The airport controller advised the crew of the wind conditions and altimeter setting and requested that they report passing the ROCK intersection, located on the localizer back course, 15 distance measuring equipment (DME) miles*** from the Prince George very high frequency omnidirectional range (VOR) and on the 176-degree radial.

The aircraft was in descent through 13,000 feet asl and on J541 airway when the captain tuned number one VHF navigation receiver to the Prince George ILS frequency. The aircraft's position was 17 nautical miles south of the CHUB intersection, 48 DME miles from the Prince George VOR, and about 47 nautical miles south of the Prince George airport. The aircraft was also west of the approach localizer. (See Appendix A). At about 47 DME miles from the VOR, the track bar on the captain's horizontal situation indicator (HSI) started to move from its full right deflection position towards the centre of the instrument indicating that the aircraft was intercepting the localizer. The captain then selected the VHF NAV transfer switch to the BOTH ON 2 position in an attempt to provide ILS information to both pilots' navigation instruments. However, this action caused both pilots' navigation instruments to display VOR information being received on VHF navigation receiver number two. The ILS information being received on receiver number one was then not displayed on either pilot's navigation instruments. The first officer selected the front course ILS track of 147 degrees on his HSI, as normally required, and the track bar deflected right to display the aircraft's location with reference to the 147 degree radial of the Prince George VOR. Because of the aircraft's geographic location, this VOR display was similar to the ILS display the first officer expected to see. At about this time, a cabin attendant opened the cockpit door to report that the aircraft cabin had been prepared for the landing, and the captain acknowledged the information.

*** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

The first officer turned to the right to intercept what he thought was the back course ILS localizer and began his descent from 6,800 feet above sea level (asl) to 5,300 feet asl. Instead, he was proceeding toward the 147-degree radial of the Prince George VOR which was parallel to the ILS track, approximately seven miles to the northeast (see Appendix B). The aircraft was descending in cloud, and the terrain alert feature of the ground proximity warning system (GPWS) sensed a high rate of closure with the ground; it sounded an alert at approximately 700 feet above the ground. The first officer immediately entered a climb and levelled the aircraft at 6,800 feet. The pilots examined the information displayed on the navigation instruments and concluded that, if anything, the aircraft was above the descent profile and that the GPWS alert was not valid.

The radar controller was monitoring the aircraft's radar target, and he saw the target east of the localizer track. At 0910 PST, when the aircraft was about seven miles east of the localizer centre line, he advised the Prince George Tower that the aircraft was drifting to the east of the localizer, and he asked if the aircraft was intentionally off-track to avoid weather. The airport controller replied that she was not told of a planned deviation from track and that she would inform the flight of its radar position. She radioed Canadian 180 and asked why the aircraft was off-track. The crew did not reply to the question, and the airport controller made no further attempt to contact the flight.

At 0913 PST, Canadian 180, using DME and what was thought to be localizer information, reported by the ROCK intersection, and the airport controller cleared the pilot to land on runway 33. She noted that the aircraft's relative bearing from the tower, displayed on the tower very high frequency direction finder (VDF), was not the correct bearing for an aircraft positioned over the ROCK intersection. She did not advise the pilot of the discrepancy.

At 0915 PST, two minutes after the crew reported that they were by the ROCK intersection and five minutes after the radar controller first warned that the aircraft was east of the required track, the radar controller asked the airport controller what reason the pilot had given for being off-track. The airport controller replied that she did not know the reason. The radar controller then said that the aircraft was still off-track, and he warned that the flight was in danger. The airport controller relayed the radar controller's information to the crew.

Meanwhile, after crossing what the crew believed to be the ROCK intersection, the first officer started a descent from 6,800 feet asl to follow the approach procedure to the minimum descent altitude (MDA) of 2,660 feet asl. The crew heard the warning from the airport controller and the GPWS warning at about the same time as the aircraft descended to within 1,000 feet of the high ground. The captain saw the ground through the cloud as he ordered the first officer to pull up. The first officer complied and climbed to a safe altitude. The crew then discovered the VHF NAV switch selection error.

The incident occurred at lat 53°40'N, long 122°25'W at 0915 PST during the hours of daylight.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	5	91	-	96
Total	5	91	-	96

1.3 Damage to Aircraft

There was no damage to the aircraft.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

1.5.1 Pilots

	Pilot-In-Command	Co-Pilot
Age	51	38
Pilot Licence	Airline Transport	Airline Transport
Medical Expiry Date	Valid	Valid
Total Flying Time	12,955 hr	7,750 hr
Total on Type	1,239 hr	1,040 hr
Total Last 90 Days	128 hr	178 hr
Total on Type Last 90 Days	128 hr	178 hr
Hours on Duty Prior to Occurrence	2 hr	2 hr
Hours off Duty Prior to Work Period	72 hr	12 hr

Both pilots were licensed and qualified on Boeing 737 aircraft; however, it was both pilots' first flight on a B737 with this cockpit layout. Both had recently attended a CAIL company course, approved by Transport Canada, to qualify them to fly the aircraft. At the time of the incident, the aircraft was being flown by the first officer from the right seat.

1.5.2 Air Traffic Controllers

Controller Position	Prince George Sector Radar	Prince George Airport
Age	40	22
Licence	Valid	Valid
Medical Expiry Date	October 1988	October 1988
Experience		
- as a Controller	13 yr	16 mo
- as an IFR Controller	8 yr	N/A
- in Present Unit	8 yr	7 mo
Hours on Duty Prior to Occurrence	2.5 hr	2.5 hr
Hours off Duty Prior to Work Period	16 hr	16 hr

The Prince George Airport Controller received air traffic control training while she attended Collège d'enseignement général et professionnel (CÉGEP), in the Province of Quebec. She also attended the air traffic control (ATC) basic training course at the Transport Canada Training Institute at Cornwall, Ontario. After graduation, she was employed as a airport controller at the Boundary Bay Airport, British Columbia. When she transferred to the Prince George Airport Tower, she received on-the-job training to qualify in both ground and airport control.

The control of VFR and IFR traffic was stressed during all levels of her training, and she had successfully completed written and practical examinations to demonstrate her proficiency and knowledge of the subject.

1.6 Aircraft Information

Manufacturer	Boeing Commercial Aircraft Co. USA
Type	Boeing 737-275C
Year of Manufacture	1975
Serial Number	21294
Certificate of Airworthiness	Valid
Total Airframe Time	30,050 hr
Engine Type (2)	Pratt & Whitney JT8D-9A
Maximum Allowable Take-off Weight	117,000 lb
Recommended Fuel Types	Jet A, Jet B

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The weight and centre of gravity were within the prescribed limits.

1.7 Meteorological Information

The Prince George weather forecast, issued at 0230 PST on 24 November, called for scattered clouds at 1,500 feet, broken clouds at 4,000 feet, and overcast clouds at 8,000 feet. The wind was to be from the south at 12 knots with gusts. Occasionally, the visibility was to be three miles due to a mixture of light rain and snow. During this time, the sky would be partially obscured by the precipitation, and the sky would be overcast at 1,000 feet.

The following upper level wind values are valid for Prince George at 0400 PST, 24 November 1987. They are representative of the winds an aircraft would encounter while descending over Prince George at 0900 PST. The tail wind component was computed for the direct track between Vancouver and Prince George.

Altitude	Magnetic Direction	Speed	Tail Wind Component
4,000 ft	146°	16 kt	10 kt
6,000 ft	146°	36 kt	35 kt
8,000 ft	166°	37 kt	37 kt
10,000 ft	171°	32 kt	30 kt
12,000 ft	181°	19 kt	18 kt
14,000 ft	186°	32 kt	28 kt
17,000 ft	191°	44 kt	38 kt
20,000 ft	191°	51 kt	44 kt

The captain reported that the cloud tops were about 15,000 feet and that there was snow in the clouds. During the pull-up after the GPWS sounded the second time, he saw the ground through the broken cloud. The Prince George Airport Controller reported that, east of the airport and in the vicinity of the aircraft, the mountain tops were obscured by clouds.

A weather special for Prince George issued at 0833 PST reported scattered cloud at 300 and 1,600 feet above ground level (agl), broken cloud at 3,500 feet agl, and overcast cloud at 9,000 feet. The visibility was six miles in fog. The 0900 PST weather observation reported that the broken layer at 3,500 feet had become scattered and that a new broken layer had formed and was based at 5,000 feet. The visibility had increased to eight miles.

1.8 Aids to Navigation

1.8.1 Aircraft Navigation Aids

The aircraft navigation equipment required to fly the instrument approach to runway 33 was serviceable at the time of the incident. However, because of the mis-selection of the VHF NAV transfer switch, the pilots' instruments were not displaying the required information.

1.8.2 Airport Navigation Aids

The Prince George VOR/DME site is located on Tabor Mountain, seven miles east of the airport. There is no DME at the Prince George Airport.

The Prince George Airport is served by instrument approach procedures to runways 15 and 33. The airport radio navigation equipment required for the instrument approaches was reported to be serviceable and operating normally at the time of the incident.

The approaches (all non-precision) to runway 33 have the same minimum descent altitude of 2,660 feet asl (445 feet agl) whichever approach aids are used.

1.8.3 Automatic Direction Finding (ADF) Errors

The ADF is subject to errors which affect the accuracy of the bearing received. Two errors applicable in this instance are described below. The effects in both cases are diminished when the transmitter has a strong signal or when the receiving aircraft is close to the transmitter.

1.8.3.1 Precipitation Static

When the ADF is used as a low frequency receiver, precipitation static may make reception noisy. In addition, areas of ice crystals may cause the bearing pointer to fluctuate excessively or give an erroneous indication.

1.8.3.2 Mountain Effect

The reflection of radio waves from mountains may cause fluctuations of the ADF bearing pointer. Sometimes, the radio waves can be split or bent in the vicinity of mountains.

1.8.4 Tower Very High Frequency Direction Finder (VDF)

The Prince George Tower was equipped with a VDF receiver, and it was in operation at the time of the occurrence.

1.8.5 Air Traffic Control Radar

The radar site servicing the Prince George Airport is located at Mount Baldy Hughes, 22 miles southwest of the airport. Minimum radar vectoring altitudes have been established; however, radar controllers are able to "see" aircraft down to landing at the airport. There were no known radar deficiencies that affected the ATC controller's ability to track radar targets.

The computer record of the radar track of the aircraft was plotted on a map (see Appendix B). The track is represented by dots numbered consecutively from 15 to 85.

1.8.6 Very High Frequency Navigation (VHF NAV) Receivers

The aircraft is equipped with two VHF NAV receivers. The information received by the VHF NAV receivers is routed through a three-position VHF NAV transfer switch (see Appendix C). The receivers are located on the forward electronic panel, and the transfer switch is located on the captain's forward overhead panel. The receiver controls are not identical in all Boeing 737 aircraft operated by CAIL.

1.8.7 Distance Measuring Equipment (DME) Hold

A DME hold, if available and if selected, will allow the VHF NAV receivers to be tuned from a VOR/DME frequency to another VOR/DME or ILS frequency and still receive the DME information from the former station. Six Boeing 737 aircraft out of 66 operated by CAIL are equipped with DME hold; this aircraft was not so equipped.

1.8.8 VHF NAV Transfer Switch

The Boeing 737 aircraft operations manual states that the purpose of the VHF NAV (receiver) transfer switch is to enable both pilot positions to receive information from one of the VHF NAV receivers in the event the other receiver is unserviceable. At the time of the occurrence, some former CPAL pilots routinely used the switch for normal operations; some CAIL training pilots discouraged its use, and some advocated its use. The company standard operating procedures manual did not address the use of the transfer switch.

With the VHF NAV transfer switch in the centre, NORMAL position, each pilot's navigation instruments receive information from their respective VHF navigation receiver. A BOTH ON 1 or BOTH ON 2 selection routes the selected navigation receiver information to both pilots' navigation instruments (see Appendix D). On some CAIL aircraft, an annunciator light, visible to the pilots, is turned on when the transfer switch is not in the NORMAL position. The annunciator light does not identify the receiver providing the navigation information, and, other than by direct observation of the position of the transfer switch, there is no cockpit indication of which receiver is selected. The first officer stated that he had seen the switch used on previous flights. The captain said that he had used the VHF NAV transfer switch on other occasions and that the annunciator light reminded him to verify and monitor the receiver in use. Former PWA aircraft are not equipped with the annunciator light.

1.8.9 Horizontal Situation Indicator (HSI) Displays

The HSI can be used to display the aircraft's relative position with reference to an ILS localizer track or to a VOR radial (see Appendix E). It effectively provides a plan view of the navigation display.

With the VHF navigation receiver tuned to a VOR station and a radial (or its reciprocal) selected in the HSI course window, the HSI track deviation bar will display the aircraft's position relative to the selected radial when the aircraft is within 14 degrees of the radial. The HSI will also display a "to/from" ambiguity indicator pointer when the instrument is receiving VOR information.

When a VHF NAV receiver is tuned to an ILS facility, the HSI track deviation bar will begin to display the aircraft's position in relation to the localizer centre line when the aircraft is within three degrees of the centre line. The position of the track bar is independent of the heading selected in the HSI course window. The "to/from" ambiguity indicator pointer is not in view when the instrument is receiving ILS information.

When the HSI is receiving ILS information, the glide slope pointer and scale are in view; however, they will normally be masked by a glide slope failure flag if the ILS localizer is a back course. The glide slope pointer is not in view when the instrument is receiving VOR information.

1.8.10 Attitude Director Indicator (ADI) Displays

The ADI glide slope warning flag will normally be in view, masking the glide slope pointer, when the glide slope information is unreliable and the VHF NAV receiver is tuned to an ILS facility (see Appendix F). The warning flag and the glide slope pointer will not be in view if the VHF NAV receiver is tuned to a VOR frequency.

1.8.11 Approach Procedure - Runway 33

Glide path information signals are normally suppressed in the back course approach area; however, the Prince George localizer back course VOR DME-1 approach to runway 33 is reputed to have a high incidence of glide path signal information transmitted along the localizer approach path. This glide path signal, if it is strong enough to be received by an aircraft, will cause glide path information to be displayed by the aircraft's HSI and ADI. If the signal strength varies above and below the strength required to produce a glide path display, the glide slope failure flag will be alternately in and out of the instruments' glide path display windows. If the glide path signal is received at a strength that is constantly above the minimum value, glide path information will be constantly displayed by the HSI and ADI. Text on the instrument approach plate directs the pilot to ignore the glide path indications.

Pilots are cautioned not to use glide path information when they are flying a back course approach; however, they will normally monitor and interpret all instrument displays, including false or unusable glide path information.

The approach procedure for the Prince George localizer back course VOR DME-1 approach to runway 33 is attached at Appendix A.

1.8.12 Approach Preparation

In preparation for the approach to the Prince George Airport, the ILS frequency was tuned to the number one (captain's) VHF navigation receiver when the aircraft was still 48 DME miles from the Prince George VOR, and the back course track guidance information was displayed on the captain's instruments. The number two (first officer's) VHF navigation receiver was tuned to the Prince George VOR frequency to enable the first officer to navigate on the airway. The first officer requested that, when the number one navigation receiver began to receive localizer information, the VHF navigation receivers be tuned in reverse order to

display the VOR on the captain's side and the ILS information on the first officer's side. The number one automatic direction finding (ADF) receiver was tuned to the Prince George non-directional beacon (NDB), the outer marker for the back course approach to runway 33; and the number two ADF was tuned to the X-Ray NDB, the missed approach beacon. The ADF/VOR bearing pointer switches were selected to ADF at both pilot positions. Both beacons were identified; however, according to the pilots, the bearing indications were erratic and unreliable.

The captain had planned to transfer the ILS navigation information to the first officer's instruments when the aircraft intercepted the ILS localizer rather than to tune the navigation receivers as requested by the first officer. This was to be accomplished by selecting the VHF NAV transfer switch from the NORMAL position to the BOTH ON 1 position. Both pilot positions would then display the ILS information. Because the number two navigation receiver was still tuned to the Prince George VOR frequency, distance information was available from the DME. The use of the VHF NAV transfer switch was not discussed when the pilots prepared for the approach to runway 15, nor was it discussed when the first officer amended the approach briefing after the designated approach and landing runway was changed.

1.9 Communications

1.9.1 ATC Radio Procedures

As CAIL Flight 180 approached Prince George, the radar controller directed the aircraft captain to contact the Prince George Airport Controller. This was to enable the airport controller to advise the captain of local aircraft traffic and aerodrome conditions. Any further instructions from the radar controller to the flight could be relayed through the airport controller.

1.9.2 Aircraft VHF Radios

Some Boeing 737 aircraft that had been operated by CPAL, the pilots' former employer, were equipped with three VHF transceivers, and some were equipped with two; all Boeing 737 aircraft operated by PWA had two VHF transceivers. As this aircraft was formerly operated by PWA, it was equipped with two VHF transceivers (see Appendix G). The radio controls are not the same in all Boeing 737 aircraft operated by CAIL. This aircraft has a rotary master volume control for each radio, and it is located in the centre of its

respective rotary frequency selector control. Because of the proximity of the two controls, it is easy to inadvertently alter the master volume control setting when changing the radio frequency. If a master volume control is set to its minimum position, neither an incoming signal nor a transmitter side-tone will be audible to either pilot.

1.10 Aerodrome Information

Not applicable.

1.11 Flight Recorders

The aircraft was equipped with a Teledyne digital flight data recording system using the ARINC 573 data format with a Lockheed 209 recorder, monitoring 20 measured parameters and eight bi-state signals. A Collins 642C-1 cockpit voice recorder was also installed.

1.11.1 Digital Flight Data Recorder

The digital flight data recorder (DFDR) was removed from the aircraft by CAIL personnel on 24 November 1987, and it was given to the Canadian Aviation Safety Board on 27 November 1987. CAIL personnel had read and copied the recorded data, and a service company may have started to service the DFDR before it was given to the CASB.

The DFDR was sent to the National Research Council Flight Recorder Playback Centre (FRPC) for analysis. It was discovered that the DFDR had malfunctioned while it was recording; however, FRPC personnel were able to recover the majority of the data. About 70 minutes of data, not related to the incident, was found to have been erased by the recording of a test signal after the unit had been removed from the aircraft. It was not determined how or when this occurred.

The aircraft's altitude and track information used in the FRPC analysis was derived from ATC radar and DFDR data.

1.11.2 Cockpit Voice Recorder

The cockpit voice recorder (CVR) information was recovered and transcribed by the NRC FRPC. Thirty-two minutes of recordings, including eight minutes while the aircraft was still airborne, was retained by the CVR.

The CVR tape is on an 'endless reel', capable of recording and retaining the preceding 30 minutes of cockpit voice activity. Any earlier conversations are taped over. The incident took place more than 30 minutes before power was removed from the CVR; therefore, conversations that took place during the incident are not on the tape. However, the pilots' comments on the tape were useful in establishing some of the sequence of events that occurred during the approach.

1.12 Wreckage and Impact Information

Not applicable.

1.13 Medical Information

The medical records of both pilots indicated that the crew were in good health. In addition, there was no evidence of psychological factors affecting the crew's performance.

The captain did say that he took a .125 milligram dosage of the sleeping drug Halcion at about 1800 PST the evening before the flight, just after his evening meal. He also said that he had a glass of light white wine with the meal. He had not been to work for three days before the incident, and he had slept well the previous night. He said that he took the drug to ensure another early night's sleep so that he would be rested for the morning flight. He reported that he awoke refreshed and that he did not detect any after effects from the drug. Some weeks after the incident, the captain took the same dosage of Halcion with a glass of light white wine in an attempt to duplicate the events of the evening before the incident to study their potential effects. On this occasion, he said that he experienced some drowsiness the following morning.

The company doctor said that he had prescribed the drug to company pilots but that he had firmly stipulated that, if it was used, it was not to be taken less than 12 hours before flight, that it was only for sleep disturbances caused by circadian rhythm upset on long flights, and that not more than a .25 milligram dosage be taken for a maximum of three consecutive days. The pilot's copy of the prescription, dated 27 March 1987, referred to dosage and directed that the drug should only be taken for sleep disturbances that

are associated with time zone differences (circadian rhythm upset). The drugs in the pilot's possession were those prescribed when he was flying on international routes.

Halcion (Triazolam) is a short-acting benzadiazepine with potent hypnotic properties. Under normal circumstances, it has an elimination half-life of up to three hours. The drug reduces the time needed to fall asleep, increases duration of sleep, and decreases the number of awakenings. Some studies indicate that insomnia may occur upon discontinuation of the drug. Other important side-effects may include loss of memory for events after ingestion of the drug with alcohol (anterograde amnesia) and increased anxiety.

The captain and first officer were examined by a non-company medical doctor a few days after the incident, and the doctor's report concluded that there was no evidence of medical or performance impairment of either pilot at that time.

1.14 Fire

There was no fire.

1.15 Survival Aspects

Not applicable.

1.16 Tests and Research

CASB investigators re-created in a Transport Canada aircraft, the approach as flown by Canadian 180. With the navigation receivers tuned to the same radio aids and following the same track to the VOR, it was concluded that it would not be possible to fly the ILS descent profile without flying into the ground. The approach, as flown by the pilots of Canadian 180, was also flown in the CAIL flight simulator. The purpose of this test was to observe the basic differences between VOR and ILS flight instrument displays. The flight simulator exercise revealed that, although the instrument indications differ between a VOR and an ILS display, the source of the navigation information is not immediately obvious.

1.17 Additional Information

1.17.1 Operating Certificate and Flight Operations Manual

The flight was dispatched under the authority of the former Canadian Pacific Airline's Operating Certificate, and the crew conducted flight operations in accordance with that company's Flight Operation Manual.

1.17.2 Company Training - Combi Aircraft

Boeing 737, C-GFPW, CAIL designation number 752, is a Combi and is one of 11 similar aircraft operated by CAIL. A Combi aircraft is a Boeing 737 configured to carry passengers and cargo; the incident aircraft was configured for a full load of passengers. The passenger cabin is also modified to suit the cargo-carrying capability of the aircraft. The engines and landing gear are fitted with devices to deflect debris away from the aircraft so that it can be operated from gravel runways. Because of these deflectors, the normal gear retraction and extension speed is 180 knots, and the maximum gear extended speed is 200 knots. The standard Boeing 737 landing gear extension speed is 270 knots, and the maximum speed with the gear extended is 320 knots.

The company conducts a Transport Canada approved one-day training course designed to qualify pilots to operate the Combi aircraft in the passenger configuration from hard-surfaced runways. The lectures and a hand-out, entitled "Introduction to B737-200 Combi Aircraft", explain the basic differences between the Combi aircraft and the standard Boeing 737. The course did not include a cockpit familiarization, nor did it cover the differences in navigation and communications equipment or their associated panels or controls between the former PWA and the former CPAL aircraft. Pilots were deemed qualified to operate the Combi aircraft in the full passenger configuration after they had passed a written and oral test. Further training was required to be qualified to operate the Combi aircraft in the mixed or all-cargo configuration or to operate from gravel runways.

The captain and the first officer had both attended a Combi course; the first officer stated that about two hours were devoted to the Combi aircraft. The captain said that he was not given an oral knowledge test as was required by the course standard.

1.17.3 Aircraft Assignment

Aircraft are assigned by the company Operations Centre, and pilots are not normally advised what aircraft is assigned to their flight until they report to operations prior to their scheduled departure. In this case, the first officer contacted the CAIL Operations Centre the night before the flight, and he was advised of routine flight information, including the identification of the aircraft assigned to the flight. However, the aircraft assignment was changed overnight, and, instead of a CPAL aircraft, the crew was assigned a PWA Combi aircraft. Both pilots had recently attended a Combi course; however, neither had ever been in the Combi aircraft cockpit, and the course did not address the cockpit differences. The pilots were uncomfortable when they discovered that they would be flying a Combi aircraft, and they had to familiarize themselves with some of the equipment, such as the radios and navigation receivers, during the flight.

1.17.4 Ground Proximity Warning System (GPWS)

The aircraft was equipped with a Sundstrand, Mark II, GPWS which has two warning boundaries, Mode 2A and 2B, when it is detecting the terrain closure rate. At the time of the incident, not all CAIL aircraft were equipped with a GPWS, nor were they required to be by regulation. There was also no regulation that required installed units to be functional.

1.17.4.1 Mode 2A (Flaps Up)

If the aircraft's flaps are not in the landing position, the GPWS aural pull-up warning is armed. The warning message is "TERRAIN-TERRAIN" accompanied by the illumination of the pull-up warning lights. If the condition remains, a "WHOOP, WHOOP, PULL-UP" warning sounds, and the message is repeated at 0.75 second intervals.

If the GPWS sounds a PULL-UP warning, the pilot is required to take the corrective actions specified in the aircraft Operations Manual, that is, to immediately increase the aircraft's altitude until the threat of ground contact no longer exists.

1.17.4.2 Mode 2B (Flaps Down)

With the aircraft's flaps down, the GPWS aural pull-up warning is inhibited, and the alert message is "TERRAIN-TERRAIN", repeated at 0.75 second intervals.

The alert is accompanied by the illumination of the pull-up warning lights. The alert is activated when the aircraft is below a pre-set height above the terrain and when it exceeds a pre-set terrain closure rate.

If the GPWS sounds a TERRAIN warning while the aircraft is in instrument weather conditions, the pilot is required to take the corrective actions specified in the aircraft Operations Manual, that is, to correct the flight path or the airplane configuration.

1.17.4.3 GPWS Warning Analysis

The analysis of the flight data revealed that the GPWS was triggered twice during the time that the aircraft was off-course. The locations are plotted as numbers 5 and 12 on the map at Appendix B. The DFDR information indicated that both terrain alerts occurred while the GPWS was operating in mode 2A and that the alerts were four minutes apart. The aircraft/terrain closure rate and the radio altitude time history for both incidents penetrated the GPWS "TERRAIN-TERRAIN" warning boundary. Evidence indicated that the "WHOOP-WHOOP PULL-UP" boundary was also penetrated in the second instance. The minimum ground clearance was estimated to have been 700 feet with a closure rate of 2,400 feet per minute (fpm) and a vertical speed of about 1,500 fpm in the first instance, and 1,000 feet of clearance with a closure rate of 6,000 fpm and a vertical speed of about 3,000 fpm in the second instance.

1.17.5 Descent Procedure

On a normal descent from cruise altitude, the configuration of the Boeing 737 is such that the aircraft's landing gear, flaps, and speedbrakes are retracted. Pilots periodically compare the distance to go to the airport with the aircraft's altitude to ensure that the aircraft maintains the desired descent profile. Both the speedbrakes and landing gear may be used to increase the descent rate; however, lowering the Combi aircraft's landing gear will require a reduction in airspeed to 180 knots instead of the 270 knots for the standard model.

CAIL recommends a moderate speed in descent and a higher speed is permitted if conditions warrant. Pilots normally plan descent profiles so that moderate speeds are flown. In this instance, the crew reached the desired minimum altitudes without deploying the speedbrakes or lowering the landing gear.

1.17.6 Engine Anti-Ice

Engine anti-ice must be on during all flight operations when icing conditions exist or are anticipated. When using engine anti-ice in descent, at least 55 per cent N1 engine rpm must be maintained to provide sufficient airflow and temperature for anti-ice. Using 55 per cent N1 will increase the descent distance by approximately 25 per cent over the normal idle power descent distance.

In anticipation of icing conditions in cloud, the captain turned on the engine anti-ice before the aircraft entered cloud during the descent.

1.17.7 VHF NAV Receiver Assignment

Pilots' flying the Prince George LOC (Back-Course) VOR DME-1 (Appendix A) to runway 33 require bearing and distance information from the Prince George VOR to positively locate the ROCK and TABOR intersections. If the aircraft is not equipped with DME hold, the receiver serving the pilot flying will normally be tuned to the ILS station, and the pilot will fly the aircraft with reference to the localizer. The other VHF NAV receiver will normally be tuned to the VOR frequency, and the pilot not flying will use the VOR and DME information to locate the ROCK and TABOR intersections. This method of assigning the VHF navigation receivers is endorsed by CAIL standards officers, but the actual assignment of the navigation receivers is left to the discretion of the captain.

1.17.8 ATC Controller Duties

1.17.8.1 Flight Information

The ATC Manual of Operations (MANOPS) requires that ATC radar controllers provide radar service to an aircraft operating in airspace within radar coverage provided that the controller is satisfied with the adequacy of the radar-displayed information.

If a controller judges that an aircraft is in unsafe proximity to terrain, obstructions, or other aircraft, the controller is to inform the pilot of the aircraft.

During a declared emergency, ATC controllers will provide as much assistance as possible to the aircraft in distress, enlist the aid of all available facilities and services, and coordinate fully and completely with all agencies concerned.

1.17.8.2 Direction Finding (DF) Service

An ATC controller may use emergency DF procedures provided that the controller assesses the nature of the service required and the pilot concurs in the proposed action.

An ATC controller may request a pilot to confirm his position if, in the controller's judgment, the DF bearing and the reported position of the aircraft do not agree. If an aircraft's position remains doubtful following a request for confirmation, the controller will inform the pilot and use whatever other means are available to establish the aircraft's position.

The DF bearing from Canadian 180 and the aircraft's reported position did not agree. The airport controller later stated that she had some concern about the discrepancy; however, she did not request that the pilot confirm his position.

1.17.8.3 ILS Operation

An ATC controller is to immediately inform concerned aircraft that are in communication with the tower if faulty operation of the ILS is apparent.

1.17.8.4 Emergencies

A radar controller is required to inform the pilot of an aircraft if it appears the aircraft will deviate, or has deviated, from its assigned route or holding area. The pilot will be informed of the aircraft's position any time the controller deems it necessary.

1.17.9 Prince George Tower Operations

There was one controller on duty in the Prince George Tower. There was another Transport Canada employee in the tower cab; however, he was only there to observe the tower in operation. The aircraft traffic in the control zone was light, and the airport controller said that there were no unusual occurrences or distractions on the morning of the incident.

1.17.10 Maps

A section of 1:250,000 scale Transverse Mercator Projection Map is attached at Appendix B. The contour interval is 500 feet, and the elevations are in feet above mean sea level (msl). The aircraft's route is plotted, and its height above msl is compared with the elevation of the terrain beneath it.

1.17.11 Approach Event Timing

The ATC tower tape recording was compared with an identifiable event recorded by the aircraft's DFDR. The information was used to determine the local time and to plot the location of the event. The timing and location of the events in the following summary may not be exact but are close approximations, i.e., within a few seconds and plus or minus one-half mile.

PST Time	Event	Distance from VOR
17:10:00	1. Aircraft levels off from en-route descent	27.5 DME
17:10:30	2. Radar controller warns of track error (to tower)	26.5 DME
17:10:45	3. Airport controller requests reason for track error	26.0 DME
17:11:00	4. Aircraft begins descent to 5,300 feet asl	25.0 DME
17:11:35	5. First GPWS warning	22.0 DME
17:11:48	6. Power applied to engines	22.0 DME
17:13:32	7. Captain reports by the "ROCK" intersection	14.0 DME
17:14:18	8. Aircraft begins descent to 2,660 feet asl	12.0 DME
17:15:15	9. Second radar controller warning to tower	8.5 DME
17:15:28	10. Tower warning of track error to aircraft	8.2 DME
17:15:32	11. Second GPWS warning	8.0 DME
17:15:40	12. Aircraft engine power applied, pull-up and climb away	7.5 DME

The events are plotted by number on the map at Appendix B.

2.0 ANALYSIS

2.1 Introduction

The analysis will address the events that precipitated the navigational error and will examine why the pilots did not detect the error before the GPWS activation warned of the aircraft's proximity to the ground. The effects of stress on the pilots' performance will be assessed during discussion of the individual factors that contributed to the occurrence.

The air traffic controllers' actions will be examined to assess the appropriateness of their response to the occurrence.

2.2 Aircraft Assignment

When the crew discovered an hour before departure that they would be flying a Combi aircraft, they were uncomfortable. Although the training they had received met Transport Canada standards, there was no requirement for cockpit familiarization, and they had little opportunity to review the aircraft systems; this could have contributed to the stress levels of the pilots.

2.3 Weather

The approach was flown in cloud, and, although this is not uncommon, it does increase the level of attention required on the part of the flight crew to ensure that an approach is flown correctly and accurately.

2.4 Approach Options

Based on the surface wind conditions, the pilots had planned to fly an instrument approach to runway 15. The approach procedure had been discussed, and they had calculated the required descent profile. When ATC cleared the aircraft for the straight-in ILS back course approach to runway 33, the captain accepted the clearance, and, thus, the descent to the airport from cruising altitude was started closer to the airport than normal for a landing on runway 33. This reduced the amount of time available to the crew to complete the tasks involved in preparing for the approach. To increase the aircraft's rate of descent and to keep the aircraft's forward speed down, the pilot intended to slow the aircraft to 180 knots and lower the landing

gear. Because the engine's anti-ice system was turned on, the engines were being operated at a higher rpm and producing more thrust, resulting in a decreased rate of descent. Also, the aircraft was descending with a tail wind. As a result of these factors, the aircraft was descending through 10,000 feet when it intercepted the ILS localizer about 37 miles from the airport.

The crew did not have to use the speedbrakes, nor did they have to lower the landing gear to achieve the desired descent profile; however, during the descent from the cruising altitude, the captain was concerned about achieving and maintaining the desired descent profile, and this concern increased his level of stress. It was during the latter part of the descent that the captain inadvertently mis-selected the VHF NAV transfer switch, and it was during this period of high activity in the cockpit that the cabin attendant entered the cockpit to advise that the cabin was ready for landing. It was also the time when the Prince George Airport Controller radioed to question why the aircraft was east of the ILS localizer, a transmission the pilots did not hear.

2.5 VHF NAV Transfer Switch

At the time of the incident, there was no firm CAIL policy regarding the use of the VHF NAV transfer switch, and some pilots used the switch if they believed that it would facilitate the selection of the navigation receivers. Although the Boeing Flight Operations Manual states that the purpose of the switch is to enable selection of the opposite VHF NAV in the event of a receiver failure, it does not prohibit the use of the switch for other purposes. However, the switch is located out of the pilots' line-of-sight, and, other than by the pilot's observing the position of the switch, there is no indication as to which receiver is selected.

2.6 VHF Navigation Receiver Assignment

DME and VOR radial information from the Prince George VOR are required to locate the ROCK intersection on the LOC (Back Course) VOR DME-1 RWY 33 approach. Once the aircraft is established on the localizer, it is possible to locate the ROCK fix with DME information only; however, only the combined use of DME and radial information will positively identify the aircraft's position. As the aircraft was not equipped with a DME hold feature, one of the two VHF NAV receivers was required to be tuned to the VOR to receive the DME

information. The navigation receiver assignment suggested by the first officer met this requirement; however, the receivers would have had to be tuned in reverse order after the aircraft intercepted the ILS localizer. To change the receiver assignment at this busy time would be distracting and time consuming. The use of the VHF NAV transfer switch was quick, convenient, and eliminated the requirement to tune both receivers. However, had the VHF NAV transfer switch been positioned as the captain intended, no VOR information would have been available to allow positive identification of the CHUBB, ROCK, or TABOR intersections. The use of the VHF NAV transfer switch was not discussed by the crew.

An alternative receiver assignment was available. Both VHF NAV receivers would be tuned to the Prince George VOR, and, approaching the CHUBB intersection, the number two receiver would be tuned to the ILS. On intercepting the ILS localizer at CHUBB, the first officer would turn toward the station, and the captain would continue to monitor the VOR and DME with the number one receiver for bearing and DME information. To monitor the approach, the captain is required to glance at the first officer's instruments from time to time. This procedure eliminates the requirement to tune both VHF NAV receivers or to use the VHF NAV transfer switch. It also ensures positive aircraft positioning over the DME/Radial fixes.

2.7 Horizontal Situation Indicator and Attitude Director Indicator Information

The captain was monitoring the Prince George runway 33 ILS with his navigation instruments, and the front course track of 147 degrees was selected in his HSI course window as is required for a back course approach. The aircraft was still on J541 airway, 47 nautical miles south of the Prince George Airport and the course deviation bar had just "come alive" and had started to move toward the centre of the HSI, to indicate that the aircraft was within three degrees of the localizer centre line. Because the captain's VHF NAV receiver was tuned to the ILS frequency, his HSI "to/from" ambiguity indicator was not in view. Because the localizer was a back course and because the aircraft was beyond the range of any unsuppressed glide slope information signals, the glide slope pointer was probably masked by the glide slope failure flag. When the captain attempted to transfer the ILS course information to the first officer's instruments, he inadvertently moved the VHF NAV transfer switch to the BOTH ON 2 position and transferred the first officer's

instrument readings to his own instruments. This caused his HSI "to/from" ambiguity indicator to appear and the glide slope pointer and glide slope failure flag to disappear. This occurred because his HSI was now receiving VOR information. Had the captain been closely watching his HSI when he moved the switch, he would probably have noticed the course deviation bar shift slightly as it transitioned from the ILS to the VOR display. After the captain made the transfer switch selection, neither he nor the co-pilot verified that the flight instruments were displaying the desired information.

Before the captain moved the VHF NAV transfer switch, his ADI displayed a glide slope warning flag. This was because the number one VHF NAV receiver was tuned to an ILS frequency, and the aircraft was on the back course side of the ILS facility. The aircraft was about 47 nautical miles from the airport and out of the range of any unsuppressed glide slope information signals. The first officer's ADI glide slope warning flag was not in view because the number two VHF NAV receiver was tuned to a VOR frequency. When the captain moved the VHF NAV transfer switch to the BOTH ON 2 position, the glide slope warning flag disappeared from the captain's instrument. If the captain had made the correct selection of the transfer switch, the warning flag would have remained in view in his instrument, and a warning flag would have appeared in the first officer's instrument.

The first officer selected 147 degrees in his HSI course window at about the same time as the captain selected the VHF NAV transfer switch to BOTH ON 2. His instruments continued to display the VOR information from the number two VHF NAV receiver, and the selections caused his HSI course deviation bar to display the aircraft's intercept angle relative to the VOR 147-degree radial. Because the position of the course deviation bar is not dependent on HSI course settings, any movement of the course deviation bar when the first officer selected 147 degrees in his HSI course window would be an indication that ILS information was not being displayed by the HSI instrument. The "to/from" ambiguity indicator was still visible in the first officer's HSI; the glide slope pointer and failure flag were not visible. Because the aircraft was within 14 degrees of the VOR 147-degree radial, the HSI course deviation bar was at some point between the on-course and full scale right deflection, a display similar to what the first officer expected. As the aircraft approached the VOR 147-degree radial, the bars continued to move toward the centre "on-course" position of the instrument.

Neither the captain nor the first officer noted that their instruments were displaying VOR information. This may have been because the visual cues were subtle. Because the crew had not discussed the use of the transfer switch, the first officer was not prepared for its use. He had seen it used before, but he was not sure exactly what information his instruments would display when it was used. He had no time to question the validity of the display after the captain positioned the switch. Because it looked correct and because he saw the captain select the ILS frequency on VHF navigation radio number one, he assumed that the ILS localizer information had been transferred to his instruments. The first officer altered the aircraft's course to the right to intercept the "ILS centre line" before the aircraft reached the ROCK intersection. On interception, he turned the aircraft to the left to maintain the "on-course." ADF was selected on the RMIs; however, the information was unreliable. VOR radial information was not used to identify the intersection.

2.8 ADF Navigation Receivers

The pilots stated that, when they tuned the aircraft's ADF receivers to the Prince George and X-Ray NDBs, the radio magnetic indicators (RMI) were fluctuating, and the bearing information was unusable. The aircraft was flying in clouds and near mountains at the time, and the radio reception may have been adversely affected. Because the needles were fluctuating, the pilots disregarded the RMI bearing information. It was not until after the second GPWS warning that the crew noted the needles tended to point left, toward the NDBs. Normally, if a navigation aid is unreliable, a crew will attempt other means to receive required information. In this case, selecting VOR on the RMI would have given the crew direct VOR radial information, which would have shown that they were off the desired course.

2.9 VHF Communications Radios

The pilots had never been in the cockpit of the Combi aircraft, and they were not completely familiar with some of the radio equipment. They normally flew aircraft that were equipped with three VHF communications radios; the Combi had only two. The captain was not familiar with the radio controls, and he had inadvertently turned down the master volume control for the radio that he was attempting to use. He called Prince George Tower, but, as he was unable to

hear a transmitter side-tone, he thought that the radio had malfunctioned and that he now had the use of only one VHF radio. This radio 'failure' was of concern to the captain and added to the already considerable level of stress that he was feeling. He established radio contact with the airport controller with the second radio. Three and one-half minutes later, at 1710:45, when the Prince George Airport Controller attempted to contact the flight to ask why the aircraft was off-track, neither pilot heard the transmission. The crew could not say why they had not heard the airport controller. Both radios functioned properly when they were used after the incident.

2.10 Digital Flight Data Recorder

The DFDR analysis showed that the aircraft was over the high ground east of the runway localizer and that the GPWS warned, on two occasions, that the aircraft was in danger of flying into the ground.

2.11 Ground Proximity Warning

The minimum altitudes established for the localizer approach to runway 33 would not have provided ground clearance for CAIL Flight 180 as it approached the Prince George VOR site and, when the crew descended toward the high ground, the ground proximity warning system warned them away. The crew's reaction to the GPWS warnings, combined with the radio warning, prevented a major accident.

2.12 Medical

According to the captain, he took the sleeping drug Halcion the night before the flight, about 15 hours before the incident. Taking the drug was contrary to the CAIL company doctor's direction that the drug only be taken to induce sleep because of circadian rhythm upset. Because of the time interval between the incident and the medical examinations, it could not be determined if the drug affected his performance the day of the incident.

2.13 Air Traffic Control

As the flight approached the Prince George Airport, the radar controller instructed the aircraft captain to contact the Prince George Airport Controller. The flight was capable of navigating to its destination

without radar assistance; however, the radar controller continued to monitor the flight's progress, and he saw the target move east of track. When it was about seven miles off the runway centre line, he told the airport controller that the aircraft had drifted east of the localizer. However, he did not tell her how far the aircraft was off-track. The airport controller made an attempt to contact the flight 50 seconds before the aircraft's first encounter with high terrain. When the captain did not reply, she made no further attempt to relay the information because she reasoned that the aircraft was following close to the localizer and would soon be at the ROCK intersection and, therefore, on-track. Two minutes and 45 seconds later, the captain reported by the ROCK intersection. Although the airport controller noted that the VHF/DF bearing did not correspond to the actual ROCK intersection, she did not inform the crew. One minute and 20 seconds after the captain reported by the ROCK intersection, the radar controller warned that the flight was well off-track and in danger, and the airport controller relayed the radar controller's warning. Five minutes had elapsed since the radar controller's first query regarding the aircraft's position. Both air traffic controllers were aware that the aircraft was deviating from the published approach track, but they did not ensure the crew was aware that the aircraft was not on the desired track in time to avoid the near collisions with the ground. The controllers' second warning may have reinforced the crew's acceptance that the GPWS warning was real.

3.0 CONCLUSIONS

3.1 Findings

1. The pilots had not been in the cockpit of a Combi aircraft before and were unfamiliar with some of the differences in the cockpit equipment and layout, and their Combi training did not include instruction on the differences in the cockpit equipment and layout.

2. The VHF NAV transfer switch is out of the pilots' normal field of vision, and there are no visual cues about its position other than by direct observation of the switch.

3. The purpose of the VHF NAV transfer switch, as stated in the Boeing 737 Operations Manual, is to provide a means of selecting the opposite VHF NAV receiver in the event of a receiver failure. However, some CAIL pilots routinely used the switch for normal operations.

4. CAIL standard operating procedures did not address the use of the VHF NAV transfer switch.

5. The captain mis-selected the VHF NAV transfer switch, which resulted in the VOR information instead of the ILS information being displayed on both pilots' navigation instruments.

6. After the VHF NAV transfer switch selection was made, neither pilot confirmed that the desired result was achieved.

7. Neither pilot recognized that the approach was being flown with reference to the wrong navigation facility.

8. VOR radial information was not used to confirm that the aircraft was at what the crew believed was the ROCK intersection.

9. The approach was flown on a track which took the aircraft into an area of high terrain.

10. The GPWS warned of the aircraft's proximity to the ground on two separate occasions. The crew's reactions to the warnings prevented an accident.

11. The radar controller advised the Prince George Airport Controller on two occasions of the aircraft's deviation from course.

12. The airport controller did not ensure that her first "off-course" message was received by the crew.

13. Although the airport controller noted that the VHF/DF bearing did not correspond to the actual ROCK intersection, she did not inform the crew.

14. The captain took the drug Halcion about 15 hours before the incident, but it could not be determined what effect, if any, the drug had on the captain's performance.

15. The captain's use of the sleeping drug Halcion was not in accordance with the company doctor's instructions or the doctor's prescription.

16. There are no Transport Canada regulations or guidelines regarding the prescribing of short-acting hypnotic drugs to flight crews.

17. The pilots were certified and qualified for the flight in accordance with existing regulations.

18. The air traffic controllers were qualified and licensed to perform their assigned duties.

19. The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

20. There was no evidence found of any airframe failure or system malfunction prior to or during the flight.

21. Although not required by regulation, the aircraft was equipped with a GPWS.

22. The 30-minute CVR tape did not provide sufficient recording time to retain information pertinent to the occurrence.

23. All the Prince George Airport navigation aids were operating normally at the time of the occurrence.

24. CAIL personnel did not preserve and protect the DFDR as is required by the CASB Regulations.

3.2 Causes

The captain mis-selected the VHF NAV transfer switch, and the pilots did not confirm that the selection produced the desired results, nor did they use all available aids during the approach. Contributing factors were the lack of a positive indication of the source of navigation information displayed on the HSI, the crew's lack of familiarity with this aircraft cockpit configuration, and inadequate training and operational guidance provided by the company. The training standards met Transport Canada guidelines; the guidelines did not include cockpit familiarization.

The air traffic controllers did not ensure that the crew was aware that the aircraft had deviated from the published approach track in time to prevent the near collisions with the ground.

4.0 SAFETY ACTION

4.1 Action Taken

4.1.1. Ground Proximity Warning System (GPWS)

In this occurrence, the warning provided by the GPWS probably saved all 96 lives on board the aircraft. Since 1979, ICAO has recommended that a GPWS be required in operations involving turbojet aircraft that are over 15 000 kilograms or authorized to carry 30 or more passengers; however, at the time of this incident, such equipment was not mandatory in Canada. Air Navigation Order, Series II, No. 22, which became effective on 09 February 1989, now requires GPWS for all commercially registered turbojet aircraft with a maximum certified take-off weight of greater than 15 000 kilograms and a passenger capacity of 10 or more.

4.1.2 VHF Navigation Transfer Switch

The Boeing 737 Aircraft Operating Manual states that the purpose of the VHF NAV transfer switch is to select the other VHF NAV set as a source of information in the event of a failure of one set; however, use of the switch for other operational reasons is not prohibited by Boeing. Subsequent to this occurrence, Canadian Airlines International issued a Flight Operations Bulletin on 25 November 1987 to their Boeing 737 crews, prohibiting the use of this switch except in the event of a VHF navigation radio failure. The content of this bulletin was incorporated into Standard Operating Procedures in April 1988.

4.2 Further Action Required

4.2.1 Cockpit Resource Management Training

The acceptance of the approach to runway 33 after planning for runway 15 increased the workload of the pilots, and, to streamline this workload, the captain elected to use the VHF NAV transfer switch, thereby eliminating the requirement to retune both radios as suggested by the first officer. Unfortunately, the captain did not inform the first officer of his decision during the approach briefing. When the captain mistakenly put the VHF NAV transfer switch to the BOTH ON 2 position (instead of the intended BOTH ON 1 position), the first officer was not prepared for that procedure, and, being busy flying the approach, he assumed that the ILS localizer information had been correctly transferred.

Breakdowns in cockpit communications frequently compromise team effectiveness in cockpit crew performance and lead to undetected errors, such as the mis-selected switch in this case. Because such breakdowns in cockpit crew performance have played an underlying role in several major aviation accidents, many major airlines are adopting some form of formal cockpit resource management training for their flight crews. Transport Canada has recognized this need and has instituted an introductory program of cockpit resource management training for its own pilots.

In view of the need for effective interpersonal communications on the flight deck during conditions of high workload, it is recommended that:

> The Department of Transport actively promote the adoption of Cockpit Resource Management training by commercial operators.
>
> CASB 90-53

4.2.2 Navigation Instrument Displays

During the descent toward the VOR, there were indications on the instruments of both pilots that VOR rather than ILS information was being displayed. However, these indications were subtle and would have required deliberate checks to identify the problem. No obvious indication was available to identify the source of the navigation information being displayed.

Recent generation cockpit displays frequently have aircraft instruments designed in accordance with the Society of Automotive Engineers Aerospace Recommended Practice 571C, which recommends that the navigation display clearly indicate its source of information. For example, new digital displays indicate "VOR 1" or "ILS 2" on the display, telling the pilot the source of the information.

Errors in navigation due to mis-selection of navigation information has been a longstanding problem. Technology now offers the means for reducing the chance of such potentially fatal errors. Therefore it is recommended that:

> The Department of Transport promote the adoption of instrument displays which clearly indicate the source of the navigation information being displayed.
>
> CASB 90-54

4.2.3 Cockpit Voice Recorder (CVR) Recording Time

In this incident, no useful information was obtained from the cockpit voice recorder because the pertinent information was erased during normal CVR operation following the incident. Although pertinent data can be preserved by removing electrical power from the recorder, this precludes the recording of further information in the event of another serious in-flight problem. Therefore, recorders are usually allowed to continue running, thus resulting in the frequent loss of valuable data.

Safety investigations conducted by the CASB have been hampered by the recording over of important occurrence data by the time the power is removed from the CVR. This incident and an accident involving a Boeing 727 at Calgary, Alberta in 1987 (Occurrence 87-W70901) are indicative of this loss of valuable information.

The CASB has previously endorsed the provisions recommended by ICAO for flight data recorders and cockpit voice recorders. These provisions call for a recording time of 120 minutes for large passenger-carrying aircraft on international flights. Furthermore, in November 1987, the CASB forwarded to the Department of Transport, a Statement of Operational Requirements which included the capabilities desired for cockpit voice recorders. These included a recording time of 120 minutes for CVRs for large passenger-carrying aircraft. More recently, after an incident at Gatwick, UK in April 1988, the Air Accidents Investigation Branch of the UK recommended that a CVR capable of retaining two hours of recording be developed and that, when available, it be made mandatory for aircraft over 5 700 kilograms.

The Board endorses the ongoing work of Transport Canada and the Federal Aviation Administration to improve standards for CVRs; however it is noted that the proposed improvements will not change the available recording time. The common 30-minute loop for CVR data is frequently too short to provide useful data for occurrence investigations. Therefore the CASB recommends that:

> The Department of Transport require that CVR recording times be increased to 120 minutes for Canadian-registered, large passenger-carrying aircraft as soon as practicable.

CASB 90-55

4.2.4 Standardization

During the airline expansion and merger activities in the 1980s, the consolidation of several Canadian air carriers into Canadian Airlines International Limited (CAIL) resulted in a fleet of 66 Boeing 737s with at least 10 different cockpit configurations. The crews had become accustomed to different sets of procedures with their former companies and aircraft. These differences in procedures and cockpit layout create considerable potential for safety problems.

Under normal flight conditions, crews undoubtedly have the reserve capacity to cope with non-standard aircraft and procedures. The introduction of poor weather, minor system failures, fatigue, or other such factors could erode this safety margin to the point that a lack of standardization could become the decisive factor in precipitating an accident. This incident is an example of the effects that non-standard procedures and cockpit layouts can have on crew performance.

When mergers are planned, procedural differences are resolved by providing appropriate training and by combining Flight Operations Manuals into a single reference. Both the training and the manuals must be approved by Transport Canada before a company can conduct flight operations. Differences in cockpit layout are more difficult to address. The options are to modify aircraft to a common standard, to man each configuration with a separate group of pilots, or to provide cross-training so that all pilots can fly all aircraft. The first two options are unattractive to air carriers because of cost and loss of flexibility; therefore, they usually choose training. This option does not eliminate the potential hazard; it merely provides a way to live with it.

Operations personnel at CP Airlines, the forerunner of CAIL, recognized the need for standardization, and a plan was proposed in May 1986 to standardize B737 equipment and cockpit layouts. That little progress was made despite a strong endorsement by a Vice-President attests to the difficulties in implementing such changes. However, it is noted that CAIL began a three-phased program for the standardization of Boeing 737 cockpit configurations in 1988.

Currently, Transport Canada permits aircraft with differences in cockpit layout but with the same Type Certificate (such as several models of the Boeing 737) to be added to fleets without considering cockpit layouts. With respect to mergers, the Air Carrier

Merger Procedures Guide, TP9908E, published by Transport Canada in July 1989 cites differences in aircraft configuration as a consideration in the approval of mergers, but only in the context that cockpit difference and type training must be completed. Cockpit standardization, either before entering service or in the form of a plan to modify aircraft gradually as they continue in service, is not mentioned.

The Board recognizes that even in periods of prolonged corporate stability, complete standardization within each company is probably an unattainable goal. Furthermore, the Board recognizes the practical constraints imposed upon Canadian air carriers by economics. Nevertheless, the Board remains concerned that even minor differences (such as different types of volume controls for the VHF radios) can become the lead event for a causal chain of events leading to a major occurrence. To the extent practicable, regulatory authorities and company officials must strive for the earliest possible attainment of standardized cockpit configurations and procedures.

Therefore the CASB recommends that:

> The Department of Transport provide guidelines (for air carriers undergoing fleet changes) that would establish goals for the standardization of cockpit configurations and the conditions under which crews can operate aircraft with differences from the standard layout.
>
> CASB 90-56

4.3 Safety Concerns

4.3.1 Controller Assertiveness

Notwithstanding that this occurrence was set up by events in the cockpit, two air traffic controllers were aware for a considerable period of time that the aircraft was deviating significantly from the localizer track. Yet, insufficient action was taken to warn the flight crew. When the radar controller perceived the hazard, his query did not convey the urgency or seriousness of the hazard to the tower controller. Then, when the tower controller received no reply to her first call to the aircraft, she did not make another attempt to contact the flight until after a second call from the radar controller four minutes later. Thus, two qualified controllers nearly witnessed the controlled flight into terrain of a

Boeing 737 with 96 persons on board. The Board is concerned that, during a period of light traffic workload, two air traffic controllers were aware that the aircraft had deviated from the published approach track but were insufficiently assertive to ensure that the aircraft crew was warned in sufficient time to avoid two near collisions with the terrain.

4.3.2 Use of Halcion

The misuse of over-the-counter medications or prescribed drugs was identified as a problem in the CASB's report on an occurrence at Schefferville, Quebec in 1985 (Occurrence 85-H50005). At that time, the Board issued Recommendation 87-12 that the Department of Transport expand its program of information dissemination pertaining to the hazards of inappropriate use of medication while flying. While Transport Canada has instituted several information programs on the hazards of drug use, the problem continues.

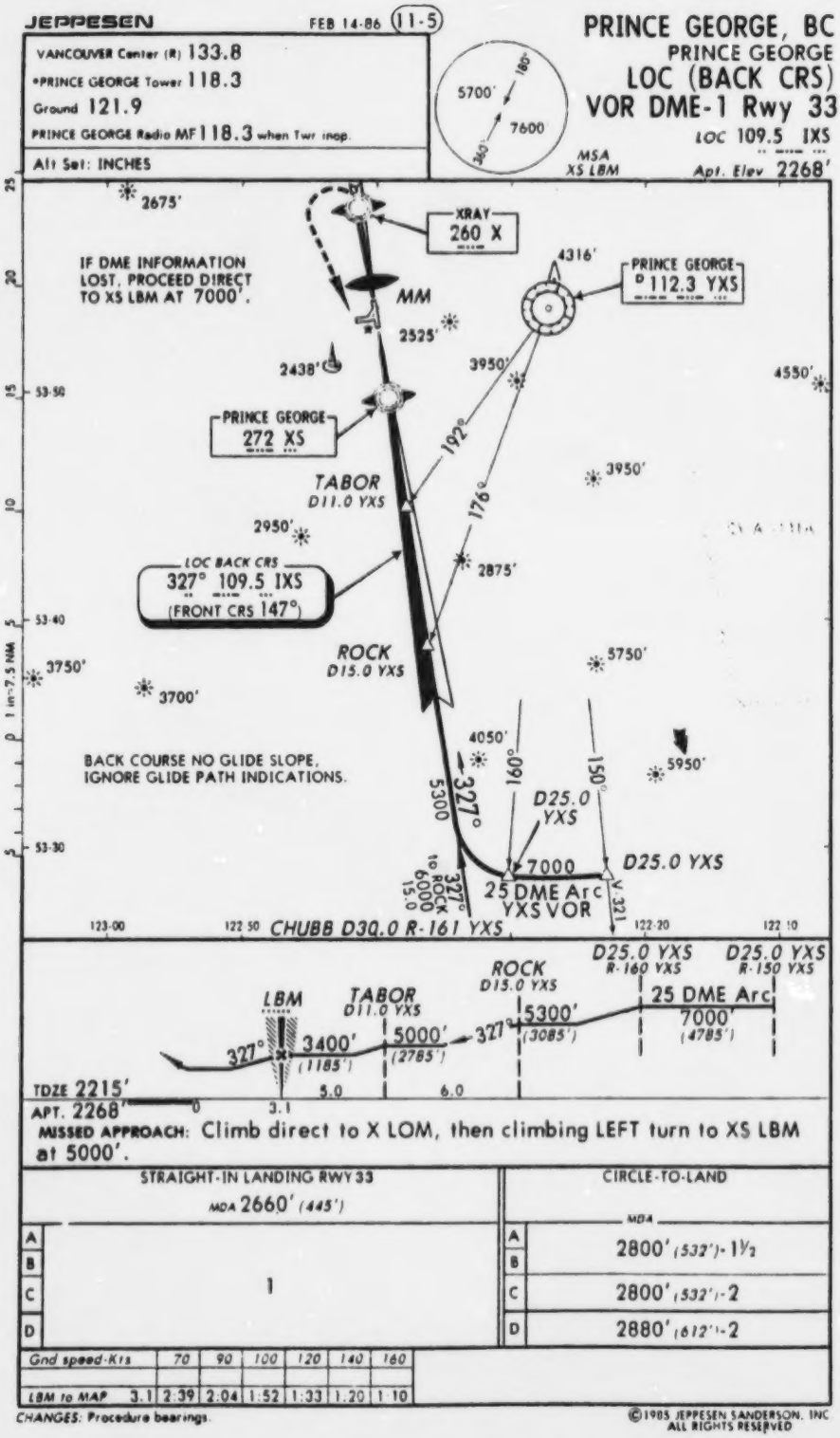
Halcion had been prescribed for the captain in March 1987 by the company doctor when the captain was flying international routes. The doctor's instructions and the pilot's copy of the prescription both stated that the drug was to be taken only for sleep disturbances associated with time zone differences on long flights. Nevertheless, the captain decided to take the drug on the night before a daytime domestic flight after three days off. That an experienced airline pilot with one of Canada's major carriers decided to take a drug contrary to the prescription instructions should be cause for continuing safety concern by both the regulatory authorities and airline management.

That the specific drug Halcion with its potential side-effects was prescribed to a pilot is also of concern. It should be noted that the CAIL doctor has stopped prescribing Halcion; however, it is understood that some doctors still prescribe it.

This report and the safety action therein has been adopted by the Chairman, K.J. Thorneycroft, and Board Members:

N. Bobbitt
W. MacEachern
A. Portelance
F. Thurston

Member R. Stevenson abstained.


JEPPESEN
FEB 14-86 (11-5)
VANCOUVER Center (R) 133.8
*PRINCE GEORGE Tower 118.3
Ground 121.9
PRINCE GEORGE Radio MF 118.3 when Twr inop.
Alt Set: INCHES
PRINCE GEORGE, BC
PRINCE GEORGE
LOC (BACK CRS)
VOR DME-1 Rwy 33
LOC 109.5 IXS
MSA
XS LBM
Apt. Elev 2268'
5700'
7600'
180°
360°
2675'
XRAY
260 X
IF DME INFORMATION LOST, PROCEED DIRECT TO XS LBM AT 7000'.
MM
2525'
2438'
4316'
PRINCE GEORGE
D 112.3 YXS
3950'
4550'
PRINCE GEORGE
272 XS
192°
176°
TABOR
D11.0 YXS
3950'
2950'
2875'
LOC BACK CRS
327° 109.5 IXS
(FRONT CRS 147°)
ROCK
D15.0 YXS
5750'
3750'
3700'
4050'
5950'
BACK COURSE NO GLIDE SLOPE, IGNORE GLIDE PATH INDICATIONS.
160°
150°
5300'
327°
D25.0 YXS
7000'
D25.0 YXS
25 DME Arc
YXS VOR
V-321
327° to ROCK 6000 15.0
53-50
53-40
53-30
1 in=7.5 NM
123.00
122.50
CHUBB D30.0 R-161 YXS
122.20
122.10
LBM
TABOR
D11.0 YXS
ROCK
D15.0 YXS
D25.0 YXS
R-160 YXS
D25.0 YXS
R-150 YXS
25 DME Arc
327°
3400'
(1185')
5000'
(2785')
5300'
(3085')
7000'
(4785')
TDZE 2215'
APT. 2268'
5.0
6.0
3.1
MISSED APPROACH: Climb direct to X LOM, then climbing LEFT turn to XS LBM at 5000'.
STRAIGHT-IN LANDING RWY 33
MDA 2660' (445')
A
B
C
D
1
CIRCLE-TO-LAND
MDA
A
B 2800' (532') - 1½
C 2800' (532') - 2
D 2880' (612') - 2
Gnd speed-Kts 70 90 100 120 140 160
LBM to MAP 3.1 2:39 2:04 1:52 1:33 1:20 1:10
CHANGES: Procedure bearings.
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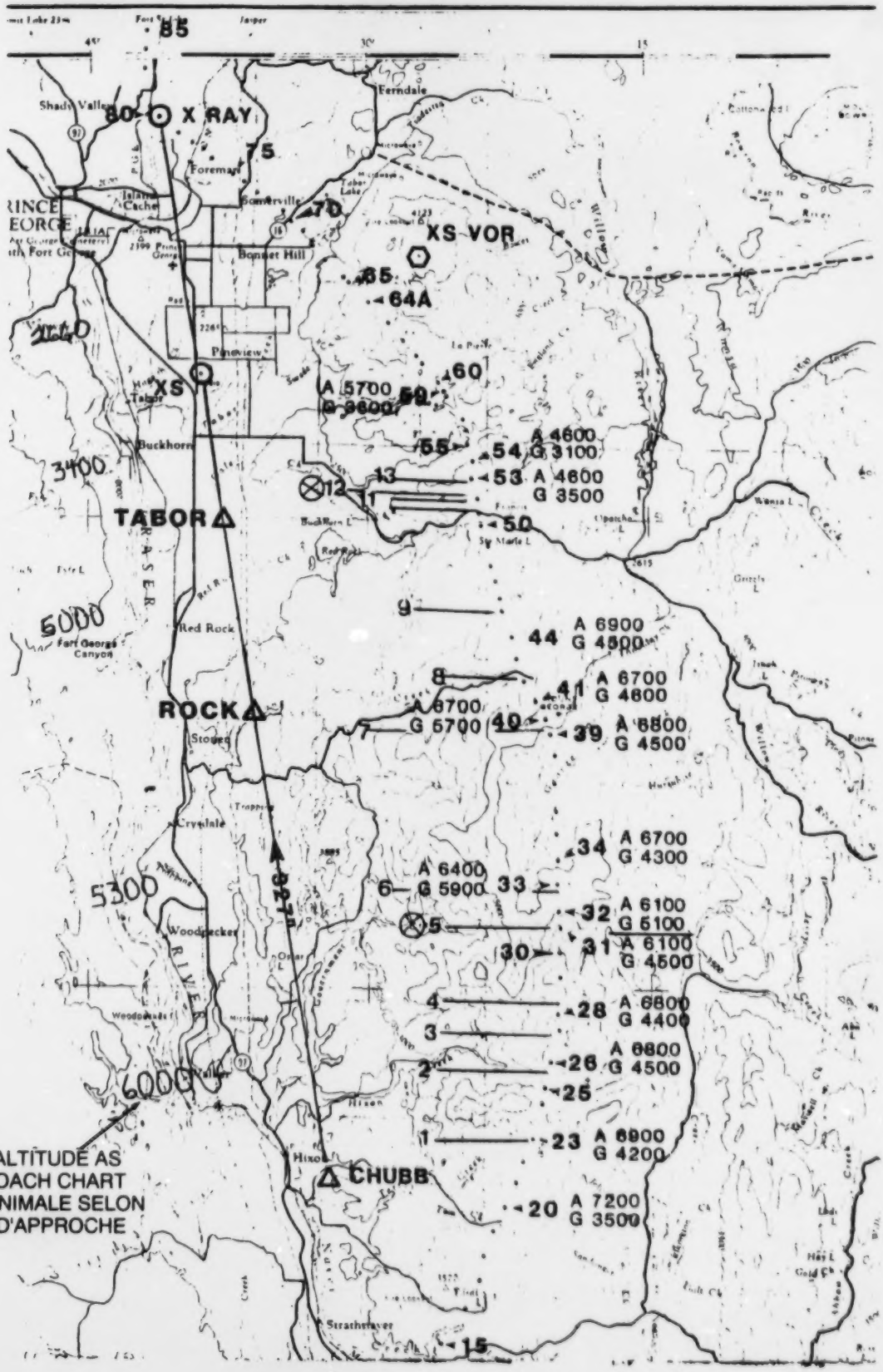
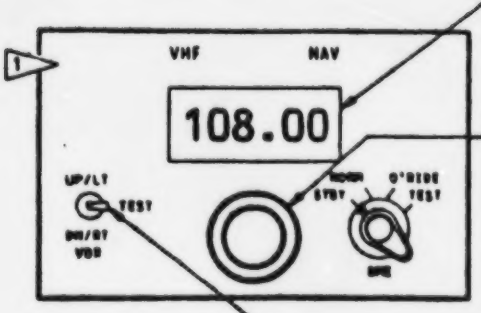
A - Aircraft height above mean sea level (feet).
Hauteur de l'avion au-dessus du niveau moyen de la mer en pieds.
G - Ground elevation above mean sea level (feet).
Altitude du terrain au-dessus du niveau moyen de la mer en pieds.

APPENDIX B
ANNEXE B





AFT ELECTRONIC PANEL

FREQUENCY INDICATOR

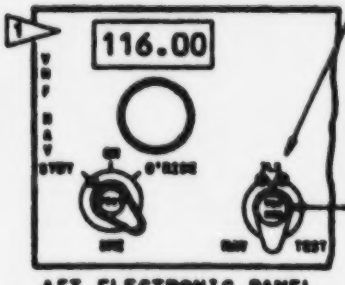
- Indicates the frequency selected by the Frequency Selector.

FREQUENCY SELECTOR

ROTATE - Manually selects the desired frequency

ILS/VOR TEST SWITCH

- UP/LT with an ILS frequency selected, the glide slope indicates one dot up and the localizer one dot left.
- DN/RT with an ILS frequency selected, the glide slope indicates one dot down and the localizer indicates one dot right.
- With VOR frequency tuned, initiates VOR TEST.

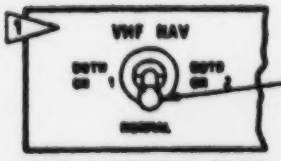


AFT ELECTRONIC PANEL

VOR/DME TEST SWITCH

With a VOR frequency tuned and a course of 000 selected:

PRESS - Course Deviation Bar centers.
- VOR Bearing Pointer indicates 180 degrees.
- TO-FROM Ambiguity Indicator shows a FROM indication.



FWD OVERHEAD PANEL

VHF NAV TRANSFER SWITCH

- Enables selection of opposite VHF NAV receiver in the event of receiver failure.

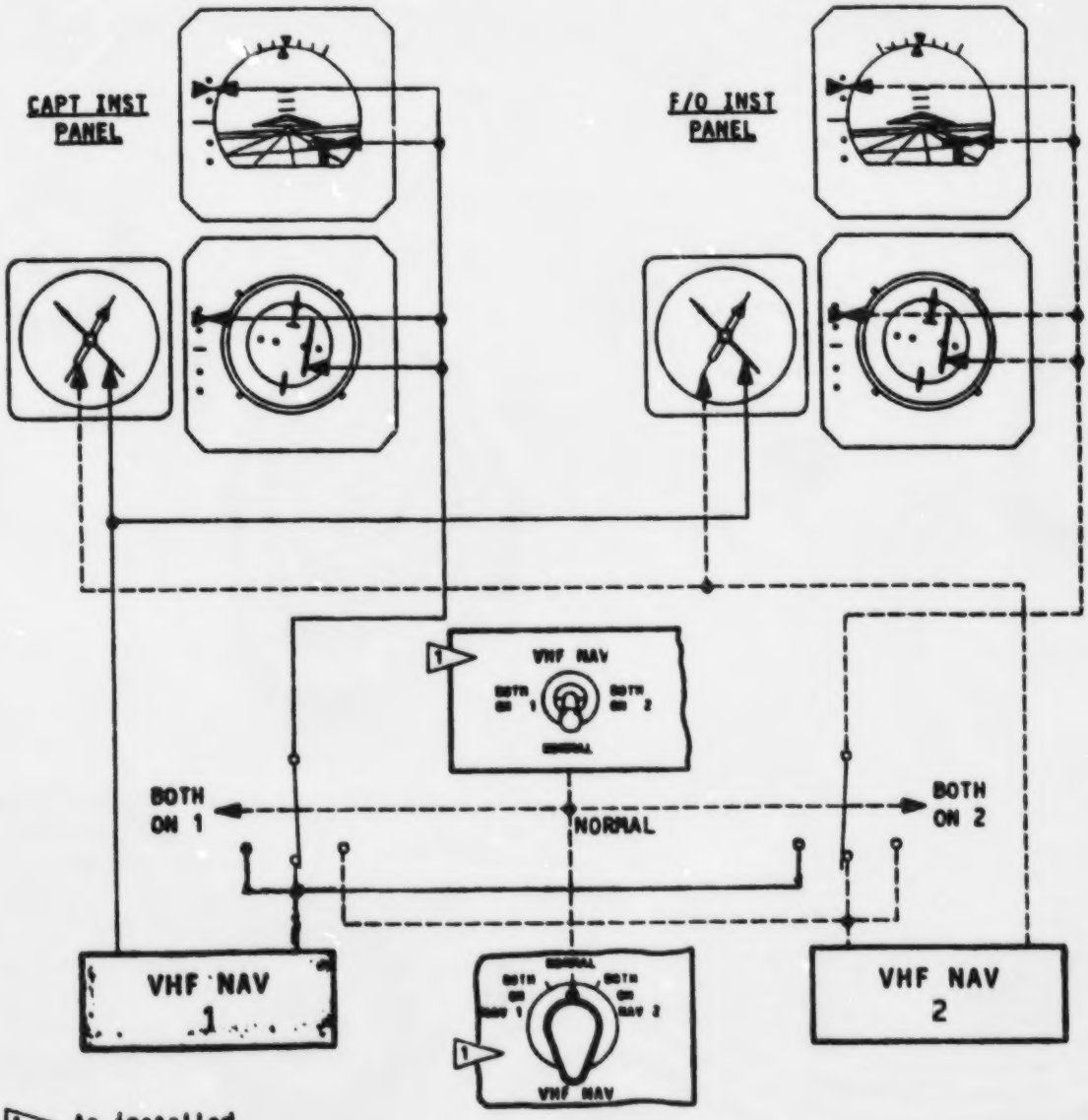
1 As installed

VHF NAVIGATION SYSTEMS

Two NAV receivers and control panels are installed. The panel is used to tune related VOR and ILS frequencies.

The VHF NAV Transfer Switch is used to transfer all associated systems to an operating receiver. Aircraft without this capability have the switch labeled INOP.

EXAMPLE: The VHF NAV switch is in the BOTH ON 2 position. The CAPT's HSI deviation bar and glide slope pointer have been switched to the No. 2 VHF NAV system. The CAPT's deviation bar and glide slope pointer move in unison with the F/O's bar and pointer and are not related to the CAPT's selected course or frequency.



VHF NAVIGATION SYSTEMS SCHEMATIC

DME MILAGE DISPLAY

- DME No. 1 on Capt's HSI.
- DME No. 2 on F/O's HSI.
- INOP on airplanes 708 thru 725.

LUBBER LINE

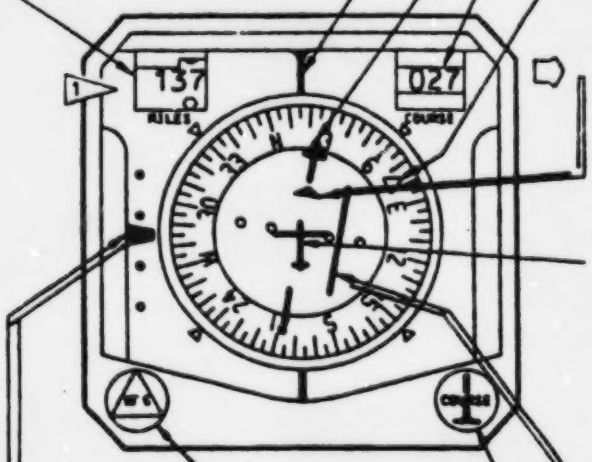
- Indicates heading on the compass card.

COURSE POINTER AND COURSE COUNTER

- Reflects the course selected by the HSI Course Selector.

HEADING MARKER

- Displays the heading set by the HSI Heading Selector.



TO/FROM AMBIGUITY INDICATOR

- Indicates direction to a VOR station along the radial selected by the HSI Course Selector.

AIRPLANE SYMBOL

- Fixed in the center of the instrument face.
- Displays position of the aircraft in relation to movable portions of the indicator.

COURSE DEVIATION BAR

VOR: 1 dot = 5 degrees.

LOC: 1 dot = 1 degree.

HSI COURSE SELECTOR

- Used to select VOR radial or LOC course for the flight director.
- CAPT selector can select a VOR radial or localizer course for the autopilot.

CAPT INST PANEL
F/O INST PANEL

GLIDE SLOPE POINTER AND SCALE

- Indicates displacement above or below glide slope.

POINTER IN VIEW - Localizer frequency tuned and HSI powered.

HSI HEADING SELECTOR

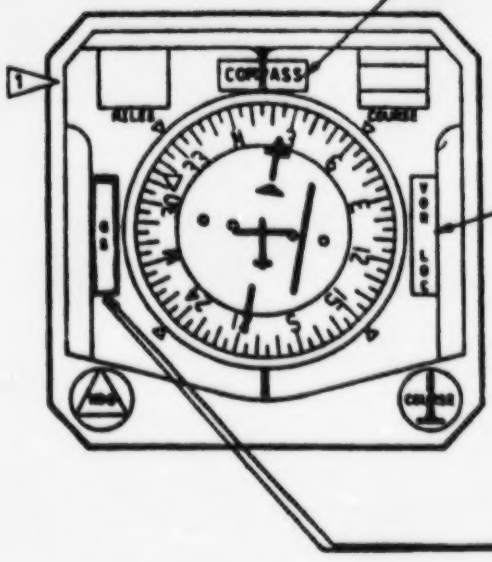
- Used to select desired flight director heading.
- CAPT selector can select a desired heading for the autopilot.

1 As installed

HORIZONTAL SITUATION INDICATOR (HSI)

COMPASS FAILURE FLAG

IN VIEW - The selected compass is invalid.
- Electrical power loss to HSI.
- Compass card malfunction.



VOR LOC FAILURE FLAG

IN VIEW - VOR or LOC signal below acceptable level.
- NAV receiver malfunction.
- Electrical power loss.

GLIDE SLOPE FAILURE FLAG

IN VIEW - ILS frequency tuned and an invalid glide slope signal.
- Failed glide slope receiver.
- Electrical power loss.

CAPT INST PANEL
F/O INST PANEL

1 As installed

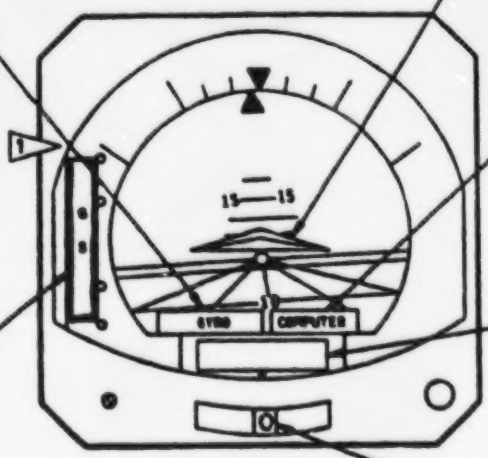
HORIZONTAL SITUATION INDICATOR (HSI)

GYRO WARNING FLAG

IN VIEW - Display is unreliable (some failures cause indications of 90 degrees left bank).
- Electrical power loss.

SYMBOLIC AIRPLANE (orange)

- Represents airplane attitude relative to the horizon.



COMPUTER WARNING FLAG

LOCALIZER SYMBOL SHUTTER

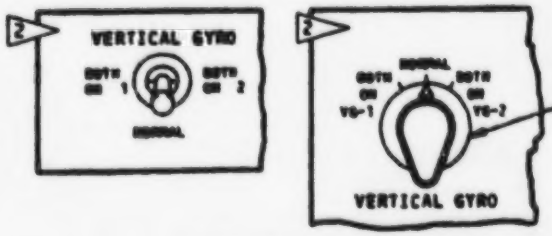
IN VIEW - Glide slope has not been captured.
- Glide slope captured but VOR LOC flag on HSI in view.

CAPT INST PANEL
F/O INST PANEL

SLIP/SKID INDICATOR

1 GLIDE SLOPE WARNING FLAG

IN VIEW - Glide slope information is unreliable with ILS frequency tuned.
- Parallels the Glide Slope Warning Flag on the HSI.



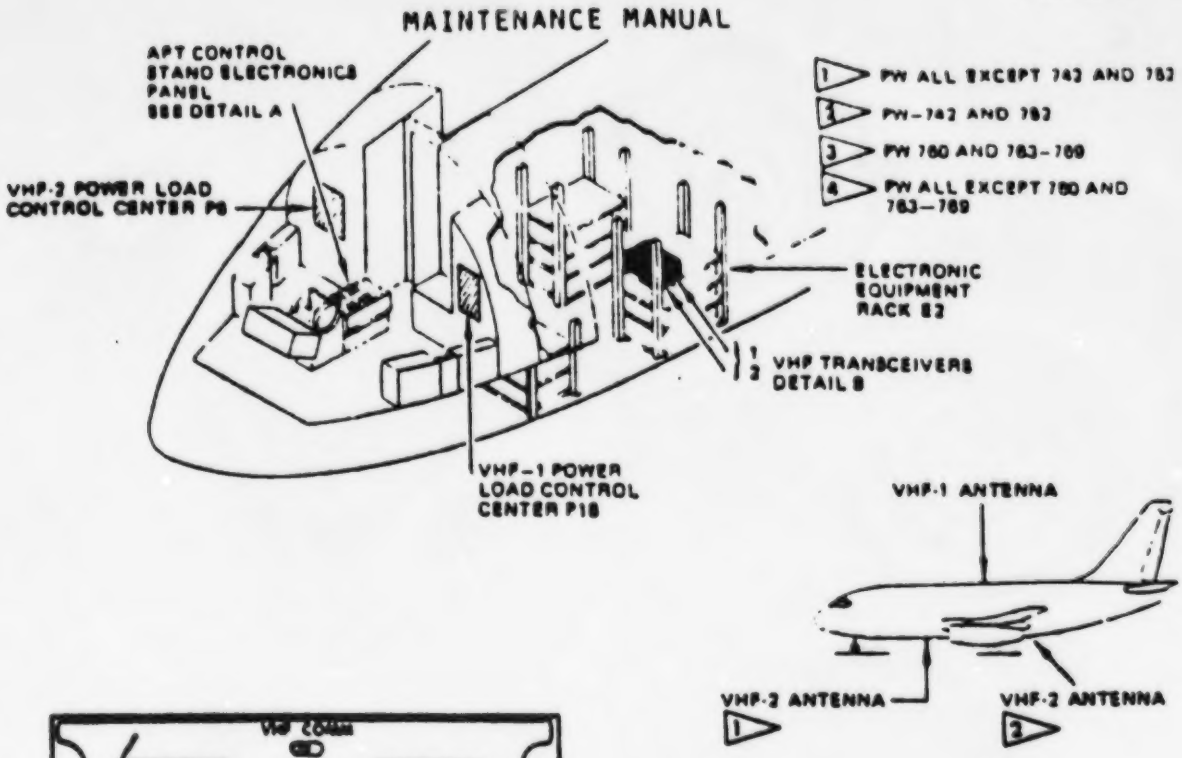
VERTICAL GYRO TRANSFER SWITCH

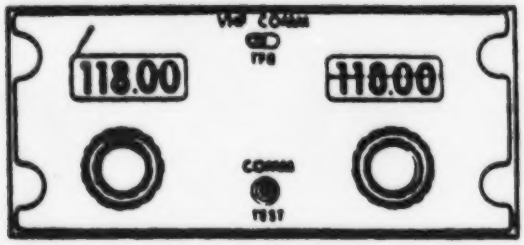
- Enables selection of the opposite vertical gyro in the event of attitude failure.

OVERHEAD PANEL

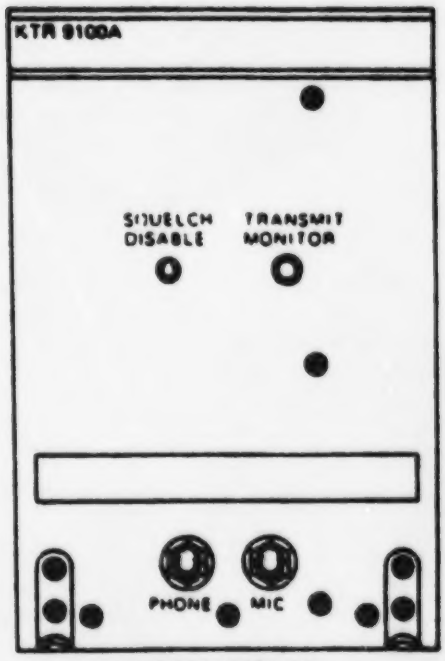
1 As installed

ATTITUDE DIRECTOR INDICATOR (ADI)

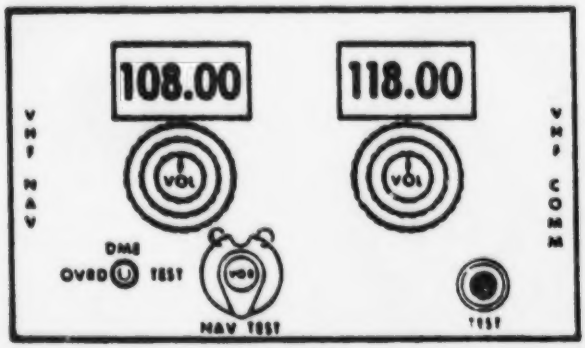

MAINTENANCE MANUAL
APT CONTROL STAND ELECTRONICS PANEL SEE DETAIL A
VHF-2 POWER LOAD CONTROL CENTER P6
VHF-1 POWER LOAD CONTROL CENTER P18
1 PW ALL EXCEPT 742 AND 782
2 PW-742 AND 782
3 PW 760 AND 763-769
4 PW ALL EXCEPT 760 AND 763-769
ELECTRONIC EQUIPMENT RACK E2
1 2 VHF TRANSCEIVERS DETAIL B
VHF-1 ANTENNA
VHF-2 ANTENNA
VHF-2 ANTENNA



VHF PANEL
DETAIL A 3



VHF TRANSCEIVER
DETAIL B



VHF PANEL
DETAIL A 4

APPENDIX H

GLOSSARY

ADF	automatic direction finding
ADI	attitude director indicator
agl	above ground level
ATC	air traffic control
asl	above sea level
CAIL	Canadian Airlines International Limited
CÉGEP	Collège d'enseignement général et professionnel
CPAL	Canadian Pacific Air Lines
CVR	cockpit voice recorder
DF	direction finder
DFDR	digital flight data recorder
DME	distance measuring equipment
FDR	flight data recorder
fpm	feet per minute
FRPC	Flight Recorder Playback Centre
ft	feet
GPWS	ground proximity warning system
HIS	horizontal situation indicator
hr	hour(s)
ILS	instrument landing system
kt	knot(s)
lat	latitude
lb	pound(s)
long	longitude
MANOPS	Manual of Operations
MDA	minimum descent altitude
mo	month(s)
msl	mean sea level
N	north
N/A	not available
NDB	non-directional beacon
PST	Pacific standard time
PWA	Pacific Western Airlines
RMI	radio magnetic indicator
UTC	Coordinated Universal Time
VDF	very high frequency direction finder
VHF	very high frequency
VHF NAV	very high frequency navigation
VOR	very high frequency omnidirectional range
W	west
yr	year(s)
°	degree(s)
'	minute(s)